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(54) Drainage tube.

(57) Subsoil drain strip or blanket comprising a core (2) surrounded by a polymer or glass fibre filter cloth (1). The core (2) has a generally planar configuration with formed-in projections (20) on one or both sides which create internal volume for flow of water as well as supporting the filter cloth (1) against imposed soil loads.

The length of the supporting projections on each side of the core is to be greater than one quarter of their closest spacing so that adequate longitudinal flow of water can take place in the strip without the need for additional drainage tubes to be provided.

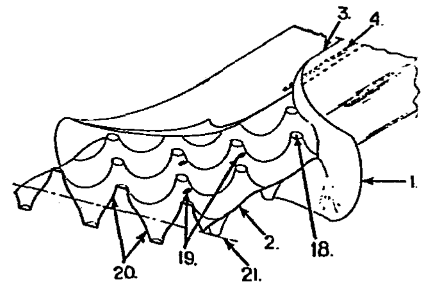

FIG 1.

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Croydon Printing Company Ltd.

DRAINAGE TUBE

BACKGROUND OF THE INVENTION

This invention relates to subsoil drainage blanket layers and in-trench drain systems for use in removing water from soil in agriculture, road building and construction, and in distributing waste water into drainage, irrigation or leach fields.

In agriculture, improved crop yields and prevention of soil salt build-up are obtained by installing subsoil drainage systems traditionally utilizing trenches, filter media such as sand, water transport media such as porous drainage pipe and water gathering media such as gravel.

The installation of such systems is costly and time consuming and can presently only be justified in intensive farming situations yielding high value crops.

Road and highway paving damage is frequently caused by surface water penetrating to the road sub-base causing a decrease in the strength of the soil and piping or washing out of the road bed under the paving joints. In addition, freezing of the road bed causes expansion of the bed under the road surface, leading to reflective cracking and spalling.

In construction, hydraulic pressure due to ground water and weakening of the foundation soil due to washing out or piping of the soil fines can cause early damage to structures. Sub-ground basement flooding and rising damp are caused by inability to remove penetrating water quickly enough.

A number of prior art systems exist to remove water penetrating a soil mass or to lower the existing ground water table. These systems traditionally include the use of sand and mineral aggregates to filter the soil from the water and to allow it to drain in combination with porous or perforated tubes to collect and lead water away. These systems usually clog after a period of time due to the passage and deposition of fine soil particles into the filter and transport media or into the tube slots or the tube itself, even when the system is carefully designed with the particle size distribution of filter media and aggregate media properly matching the native soil in the region to be drained.

In more recent times, permeable plastic polymer or glass fibre filter cloths generally called "geotextiles" have been developed which can be carefully matched in permeability to native soil characteristics and which can relatively permanently separate the native soils from the coarse aggregate used to conduct the water. Both plastic polymer and fiberglass materials are used for geotextiles. The range of cloth manufacturing techniques used includes weaving, spun bonding and melding. These provide geotextile fabrics with a wide range of properties.

Generally, geotextiles are required to be non-corrodible, rot proof and free from the long term disintegrative effects of water and water borne soil chemicals.

They are also required to have high tensile and burst strengths and have a range of water permeabilities which enable them to be matched to a wide range of native soils to provide for proper long term filtration with freedom from blocking or clogging by fine soil particles.

We refer further to a text by P. R. Rankilor entitled "Membranes in Ground Engineering" (John Wiley & Co., New York, N.Y., 1978) which fully details the technical requirements of that class of textiles defined in common use as "Geotextiles" and which discusses the drainage systems which have been developed especially for use with them.

All current drainage systems utilizing Geotextile wraps over gravel cores still require careful design and troublesome and labour intensive installation procedures and there is a need for prefabricated systems which can simplify and improve the use of geotextiles in the field. For example, it is often desired to provide drainage behind near-vertical walls. In such cases the gravel water transport medium is very difficult to deposit because it tends to slump down. Even in geotextile filter-lined trenches wherein placement of the gravel is easier, the gravel is heavy and expensive to transport, requires labour to grade and place and requires removal from the site, of the native soil it replaces.

The use of porous drainage tubes which constitute one form of prefabricated drainage system are often now made of plastic polymer and are frequently protected by filter cloths. These however, give limited water access, are subject to silting up, provide only very localized water collection, are easily crushed or accidentally disconnected, require special fittings for joins and intersections, require proper grading to maintain flow, and need careful bedding-in. When draining layered strata clay soils, such geotextile fabric covered pipes still require the installation of gravel in the trench above them, in order that they may intercept the water carrying strata.

In order to overcome the above limitations and hence, to reduce costs for installation of drainage systems, a number of prior art prefabricated systems have been developed which utilize vertical fins comprising open plastic core surrounded by polymer filter fabric to intercept and channel the subground water into drainage pipes.

Such systems as described by Healy and Long in U.S. 3,563,038 and U.S. 3,654,765 (herein incorporated by reference) offer substantially more reliable drainage systems, but are hampered by the need for careful installation and labour intensive on-site assembly of the drainage fins and the tubing into continuous lengths. The drainage tube they necessarily incorporate is an additional cost component, because the filter cloth covered fins themselves do not provide enough in-built flow capacity to conduct water away from the site quickly, without the provision of the additional pipe or conduit.

Hence, the use of such systems has been restricted to specialized drainage situations where higher on-site installed costs can be tolerated. In addition, such systems do not incorporate impermeable membranes when waterproofing of a sub-ground wall or road base is required.

Yet other flat laminated geotextile/plastic core drainage systems, as marketed in Europe and U.K. by Imperial Chemical Industries under the trademark "Filtram" comprise separation of the geotextile fabric surfaces by a laterally connective spacer such as extruded plastics net. Such systems may offer proper soil filtration with a very high ratio of water access, however the internal net spacer provides little internal volume because of its shallow structure. The edges of such a product are not usually clad by filter cloth, hence, soil can enter the system, further reducing its effectiveness. Filter fabric over net must be bonded to the net because a loose face fabric could be easily pressed into the net closing off flow. Also, because of adhesive lamination the bonded composite is stiff and inflexible.

As with the other prior art products discussed, the limited internal volume of this product requires that it drain into a slotted plastics pipe, but sealing such laminar drains into pipes involves complex and cumbersome labour intensive systems involving wrapping the slotted pipe in filter fabric and clamping it by means of bars and pegs.

In the system described by Glasser, French Patent Application No. 79,20037, some of the above limitations of the 'Filtram' system have been removed by the use of an impermeable core in which hollow projections and hollows have been formed which support a geotextile surfacing material. The height of the projections and the depth of hollows is not sufficient to provide adequate internal flow to remove the need for an additional drainage tube. In addition, it is required that the textile be bonded to the shallow core form to facilitate installation and to suspend the cloth against deflection into and subsequent blocking of the core as soil pressure is applied.

Core products are known to the inventor which have provided for the use of flat sheet on which vertical projections have been formed. For example, continuous solid plastic mouldings which consist of a flat surface on which raised pegs have been moulded at regular intervals on one or both sides. When wrapped with filter cloth, these systems suffer from not being able to be bent flexibly on a tight radius and they are not able to be joined without the need for special fittings. Such cores also require much more plastic material in their construction than the system of our invention.

SUMMARY OF THE INVENTION

The present invention provides a novel prefabricated drain which overcomes the disadvantages of the prior art systems because it:

- requires no tubing as it has sufficient internal flow carrying capacity.
- is provided in continuous lengths and hence requires no on-site assembly other than occasional end-to-end joins.
- can be installed in a narrow slit trench.
- does not require careful grading of the trench to maintain flow.
- is completely flexible and can be bent into tight curves without pinching-off.
- does not require special fittings for joins or intersections.
- can be installed because of the longitudinal bending capability, in a number of in-ground folded combinations without extra labour to give a range of drainage configurations, depending on site conditions.

- has the greatest crush strength and durability for the weight of plastic polymer from which it is constructed.
- is simple to fabricate using a high-speed continuous process for overwrapping of the core with the geotextile.

The invention provides for an internal supporting spacer or core covered or surrounded by a geotextile filter cloth. The core must be open for flow, and should have a configuration which enables it to be tightly bent or folded without damage. Such a spacer of our invention takes the general form of a flat sheet optionally perforated, on which projections or rod shapes have been formed or attached, on one or preferably both sides.

The projections must be spaced at regular close intervals, typically from one half inch to 4 inches in order to prevent flow reduction when the filter cloth is deflected due to soil pressure. For this reason and for considerations of overall flow capacity, the length of each projection must be at least one quarter of the dimension of the spacing between said projections.

The design of the core and its supporting projections is an important part of this invention. We require that the projections preferably extend from a generally planar sheet as a tapered hollow form with a generally flat top. The method and material of manufacture of such core material is not narrowly critical provided it is not corrodible, is flexible, and is not affected by water. Typically, a plastic polymer material might be chosen, such as unplasticized polyvinyl chloride, polystyrene, polyester or polyolefines such as polyethylene and polypropylene.

The projections are also to be spaced on a uniform grid pattern and these features in combination enable simple but strong joins to be made by overlapping adjacent pieces of core material so the projections nest into each other before replacing the filter cloth back over the join.

The method of assembly of the filter cloth cover over the core is not narrowly critical, it may be wrapped convolutely or helically around the core strip and seamed either with stitching or by means of a glue bead. The material of construction and design of the filter cloth is also not narrowly critical, provided it is of the general category of fabrics known as geotextiles, which have been developed to have adequate strength, durability and filter performance to be incorporated into subground drainage systems.

The filter cloth is not to be bonded or otherwise attached to the core as this causes the drain strip to become rigid and board-like, and reduces its flexibility for bending very substantially.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1	Shows a perspective view of the drain strip
Figure 2	Shows how the drain strip can be folded upon itself in either the longitudinal or transverse direction
Figure 3	Shows a single sided core alternative
Figure 4	Shows how the strip can be joined without fittings
Figure 5	Shows a completed join
Figure 6	Shows an intercepting tee join
Figure 7	Is a transverse cross section showing how the strip is installed into an in-ground trench
Figure 8	Is a transverse cross section showing how longitudinal folds in the drain strip change its in-ground drainage configuration
Figure 9	Is a transverse cross section showing how the strip is installed as a highway shoulder drain
Figure 10	Is a transverse cross section showing the strip installed as a slope stabilizing drain
Figure 11	Is a cross section showing strips installed as vertical wick drains for deep sub-ground dewatering
Figure 12	Is a graphical plot of results for flow within the drain strip core as soil pressure is applied.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In order to better describe the invention and to show its preferred embodiments, we refer again to the diagrams.

Figure I shows the assembled drainage strip of our invention, consisting of a filter cloth cover (1) wrapped around a flexible supporting core (2) with formed-in projections (20) having generally flat tops (18) optionally perforated with holes (19) said cover (1) being seamed at (3) by a bead of adhesive (4). The cloth cover is not bonded or otherwise attached to the flat tops (18) of the core projections (20) regularly disposed on each side of the central plane (21).

The core 2 of Figure 1 is a preferred embodiment, and is preferably made by the cuspation process as disclosed in U.S. Patent No. 3,963,813 which we herein incorporate by reference. Other core configurations or production methods, such as that disclosed in French Application No. 79,20037 do not enable the achievement of sufficient length in the supporting projections to enable adequate internal water flow in the strip without the provision of additional tubes.

Figure 2(a) shows a core of wavelength w and depth of projection 1/2 d. For adequate internal drainage we require that d is to be greater than 1/2 w and preferably that d = w. Figure 2(b) shows how such a core can be folded tightly upon itself without damage. This is also a necessary requirement of our invention if flexibility of installation is to be maintained.

Figure 3 shows a configuration of core wherein the projections (2) protrude only on one side of the plane 21. This core is not a preferred embodiment because it will generally require more material in its construction for the internal volume gained, at a given core crush strength.

Figures 4, 5 and 6 show how strong joins can be made in the drain strip without the need for fittings, if the core projections are regularly spaced, hollow and of a generally tapered shape.

In Figure 4 the filter cloth covers (1) have been slit and folded back. The cores (2) are overlapped and closely nested into each other. The outside of the projection (20) on the other core.

In Figure 5 the filter cloth covers have been replaced with one side overlapping the other. The join is then taped with self-adhesive tape 5.

In Figure 6 the method of construction of tee or interception joins is shown.

Figures 7 and 8 show transverse cross sections of two installations of the drain strip for draining soil. In Figure 7 the drain strip (1) is placed vertically against the side wall (6) of a narrow slit trench. The originally excavated soil (7) is then replaced as fill in the trench. The deep drain strip intercepts all of the water in any strata which it intercepts, and is especially useful for draining stratified soils. The lower section of the drain strip is optionally covered by an impermeable membrane (22) which prevents transported water from soaking back out of the strip. The deep fin configuration of the drain strip of Figure 7 has the additional advantage that even if the strip is laid into a level ungraded trench bed, the deep narrow drain strip ensures that the water in it can still flow due to the hydraulic head existing in the depth of the strip itself.

In Figure 8 the drain strip has been folded upon itself to form a more compact drain. This method of installation would be used where the soil was non-stratified and where the water table had to be lowered. Any combination of fin and fold can be readily used, between these two extreme cases.

Figure 9 shows the drainage strip installed to provide shoulder drainage for roads and highways existing or new. A slit trench (6), is cut through the road surfacing (9) at the outside shoulders. Any water entering the roadbed (8) through the road surface can then drain into the drain strip (1).

The original excavated material (7) is used to refill the trench. Surface water is normally drained away by the spoon drain or gutter (10).

Figure 10 shows how the drain strip can be installed in bench cuts (11) made in a slope (12), in order to stabilize the slope by draining it at regular intervals.

Figure 11 shows how the drain strips (1) can be installed vertically at regular intervals into a sodden soil mass (13) on which it is desired to support new loadings (14). The arrows (17) show the flow path of water from the soil pores into the drain strips, up through a membrane (16) into a drainage layer (15).

The design of cores for pre-fabricated geotextile drainage systems requires considerations of:

- Compressive Crush Strength. This is dependent upon the material thickness, the material distribution in the forming, the material type and the spacing, shape and height of the projections. U.S. Patent No. 3,963,813 gives an exhaustive treatment of the crush strength of cuspated sheet in relation to polymer, pattern and wavelength. In general, we prefer to use cuspated sheet cores which have compressive crush strengths lying between 10 psi and 80 psi. Cuspated sheet cores have uniquely good properties of compressive strength in relationship to the weight of material in them.
- Surface area Supporting the Textile. This depends on the size of the generally flat top of the truncated cusp shape and the spacing of the cusps. In coarse patterns of core with say 50 millimeter cusp spacing, relatively large flats are required on the cusps, typically from 8 to 15 mm in diameter.

In fine patterns of core such as for vertically installed lengths of drain strip as in Figure 11, very high soil loadings must be resisted without cloth damage or flow reduction. In this case fairly small flats, from one to three millimeters in diameter, are spaced at frequent intervals of say ten millimeters.

Figure 12 shows how the geotextile wrapped core of our preferred configuration performs for flow as soil load is increased. A comparison is made with "Filtram", a product comprising extruded plastic mesh bond-laminated with geotextile. The Filtram product begins to fail at soil pressures greater than about 10 psi due to the textile deflecting into and closing off the net core. The core material of our drain configuration sustains unimpeded flow at pressures up to 55 psi. Flow impedance in our system only occurs when the core itself begins to collapse due to compression failure, rather than being due to any deflection of the geotextile under soil pressure. The core of our invention comprises projections which are relatively high enough in relation to the spacing, to ensure that the deflected textile surfacing cannot close off the flow, and that the flow itself is substantially higher due to the higher degree of open space which is maintained.

Yet other configurations of the drain strip of our invention will be perceived by those skilled in the art. For example, wide strips of heavy cored product could be laid side by side, transversely across or longitudinally along the soil under a road or railway bed to provide a separation and drainage layer strong enough to resist crushing due to the combined soil and traffic loads.

The following table derived from flow testing demonstrates that the internal flow carrying capacity of the drain strips of our invention is sufficient to be equal to or better than the flow in cylindrical tubes and pipes at commonly encountered soil pressures, and can advantageously replace them with less use of polymer which is the main cost component.

COMPARISON OF 50 MM THICK DRAIN STRIP WITH STANDARD TUBE DRAINS

Strip Width (mm)	Equivalent Convoluted Tube Diameter (Equal Flow at all gradients)	Typical Weight of Polymer in Tubes (Gm. per metre)	Weight of Polymer in Drain Strip Core (Gm. per metre)	Savings in Polymer (Gm. Per metre)
150	65	200	60	140
250	75	300	100	200
500	100	450	200	250
750	125	600	300	300

The savings in plastic material in the above compared drains results because less polymer needs to be used for adequate crush strength in a vertical core of our configuration than is required to support a circular tube type drain against imposed soil loads or superimposed loads due to surface traffic.

WHAT IS CLAIMED IS:

1. An essentially continuous subsoil strip or sheet drainage material comprising an internal supporting perforated or imperforate core strip or sheet of generally planar configuration upon which is disposed on both sides of the central plane, regularly spaced supporting projections having generally flat tops, each such projection having a length greater than one quarter of its spacing, said core covered or wrapped on all four non-continuous sides with a geotextile filter cloth or other permeable surfacing material which is not attached to the core.

2. The strip or sheet material of Claim 1 further characterized in that the assembled product can be tightly folded upon itself longitudinally or transversely, without damage or significant loss of water carrying capacity.

3. An essentially continuous subsoil drainage strip or sheet, perforated or imperforate comprising a core strip or sheet surfaced on all four non-continuous sides with permeable surfacing or filtering material wherein said core has the general configuration of a flat or distorted planar surface into which hollow tapered projections with generally flat tops have been formed or attached on a regular pattern on both sides of the central plane characterized in that the height of the projections from each side of the central plane is greater than one quarter of their closest spacing.

4. The strip or sheet material of Claim 3 wherein the permeable surfacing is bonded to the flat tops of the supporting core projections.

5. The strip or sheet material of Claim 3 wherein the permeable surfacing material is seamed to form a tube shaped cover over the core said surfacing material not being bonded or attached to the core at any point.

6. An essentially continuous sub-soil drainage strip or sheet comprising a perforated or imperforate core surfaced on all four noncontinuous sides with permeable surfacing or filtering material which is not attached to said core, and wherein said core has the general configuration of a distorted planar surface into which hollow generally tapered projections have been formed on a regular pattern so that each such core can be overlapped and nested upon another piece of itself so that end to end or intercepting joins can be made without substantially increasing the cross section area of the drain at the point of joining.

7. A continuous or noncontinuous sub-soil drainage strip or sheet, comprising a flat or distorted planar internally supporting core perforated or imperforated which has disposed upon it frequent projections capable of supporting an attached or nonattached flexible permeable surfacing material covering the flat sides and two opposing edges, against imposed soil loads, characterized in that the volume created by said internal supporting core is sufficiently large in transverse cross section and sufficiently unimpeded in the longitudinal flow direction, to enable a flow of water to be maintained within the drain strip which flow is impeded less than would be the case for water flowing in a cylindrical tube of cross sectional area of no less than one eighth and no more than one quarter of the cross section area of the said drain strip, at equivalent applied hydraulic pressure per unit length of drain pipe strip or sheet.

8. A sub-soil drain utilizing the strip or sheet material of Claim 1 characterized in that the drain strip is installed into a narrow but deep slit trench said strip installed on its edge with its wide faces lying in the vertical plane, further characterized in that no additional drainage tube or member is provided.

9. A sub-soil drain utilizing the strip or sheet of Claim 1 characterized in that the drain strip is cut into lengths and installed vertically downwards into the ground at regular intervals.

10. The strip or sheet of Claim 1 further characterized in that it is surfaced over part or all of its noncontinuous sides with impermeable or waterproof sheet material.

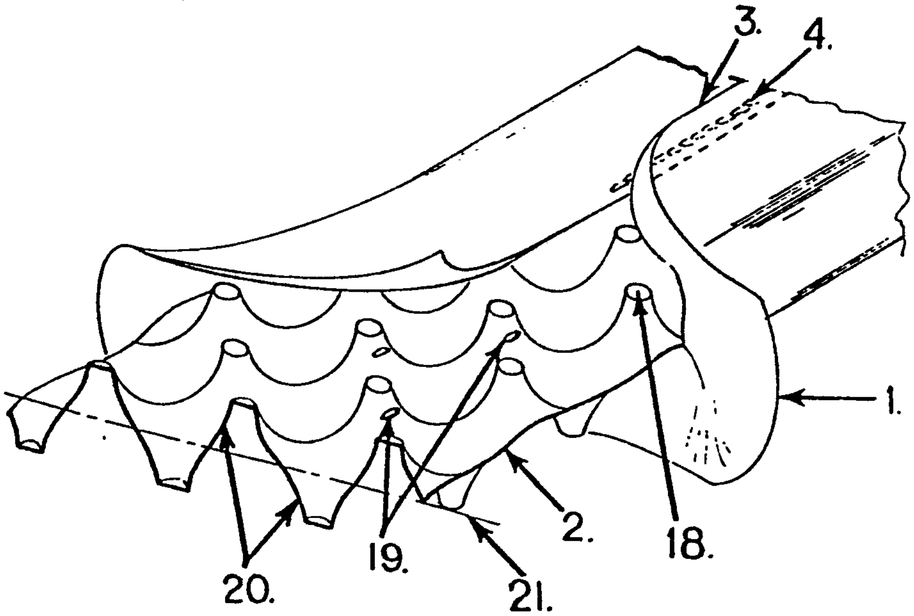

FIG 1.

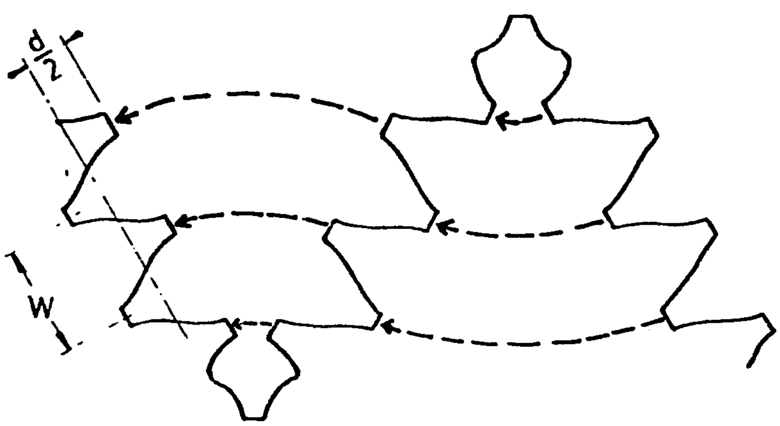

FIG 2(a)

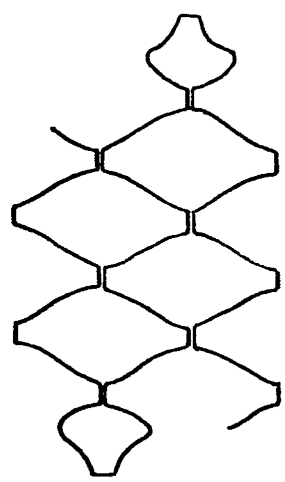

FIG 2(b)

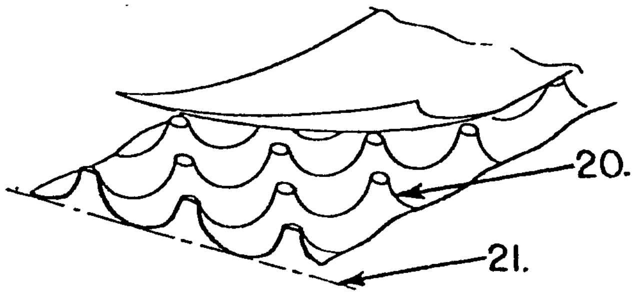

FIG 3.

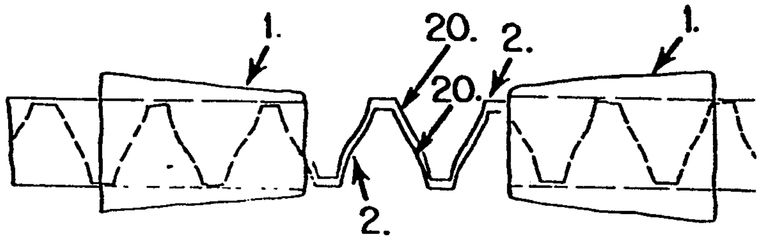

FIG 4.

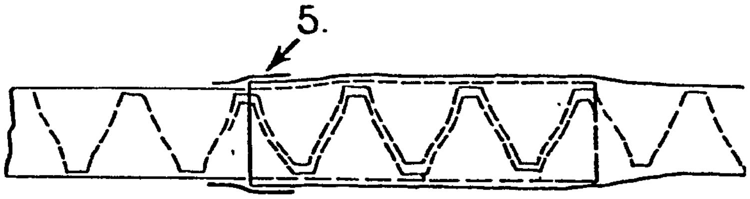

FIG 5.

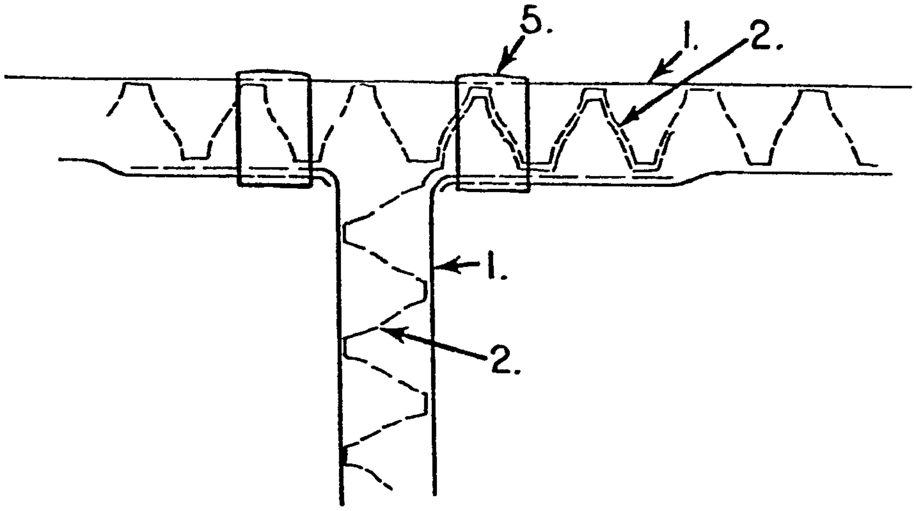

FIG 6.

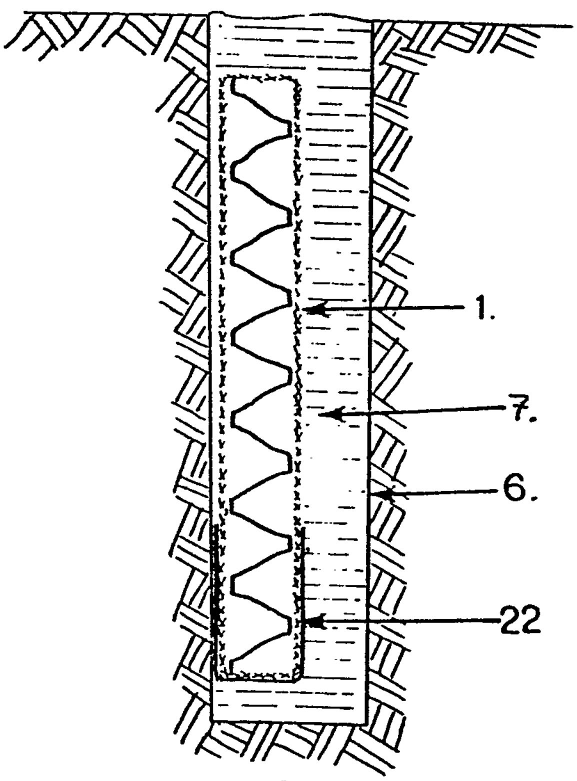

FIG 7

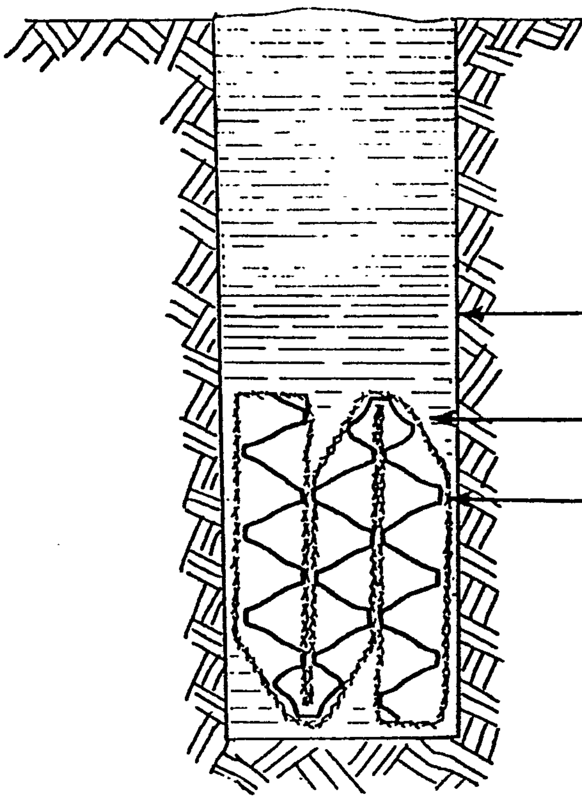

FIG 8.

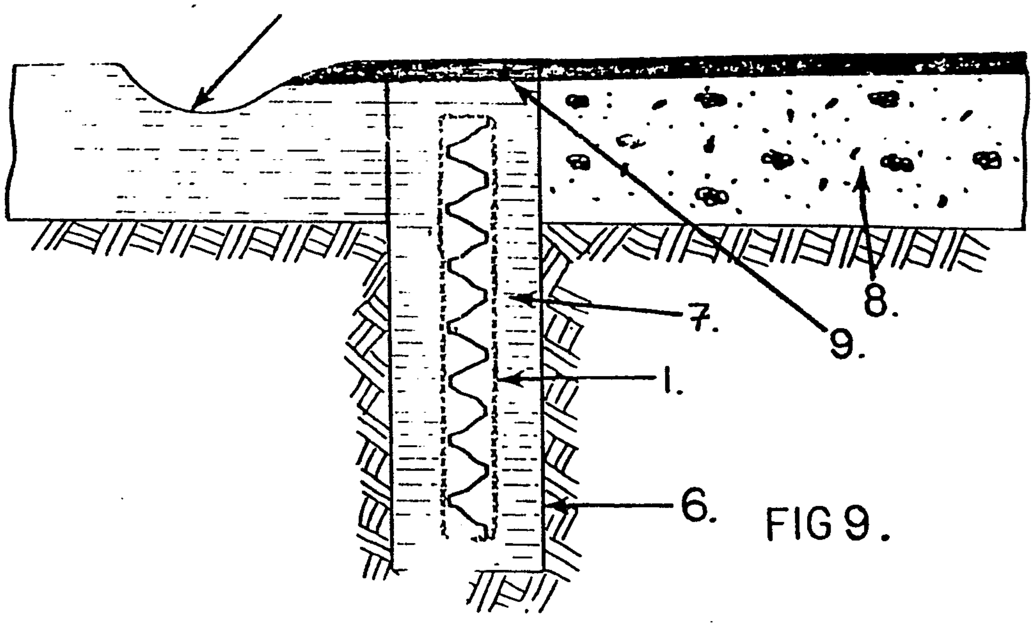

FIG 9.

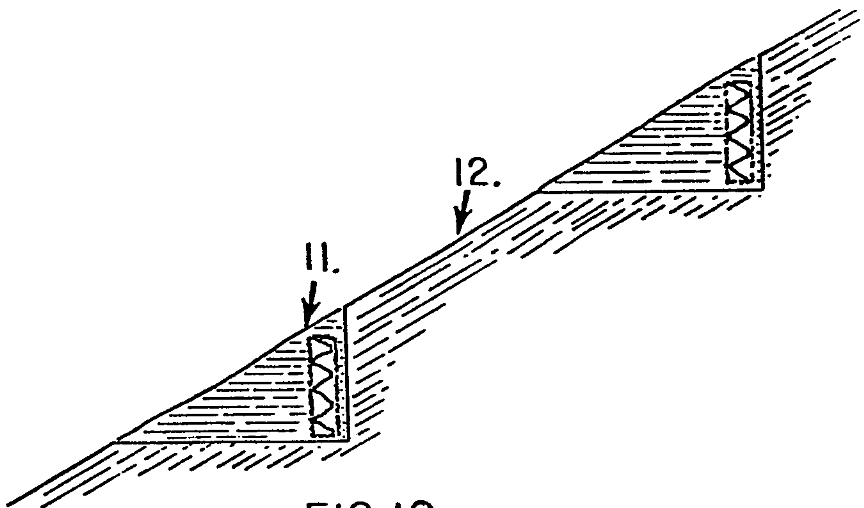

FIG 10.

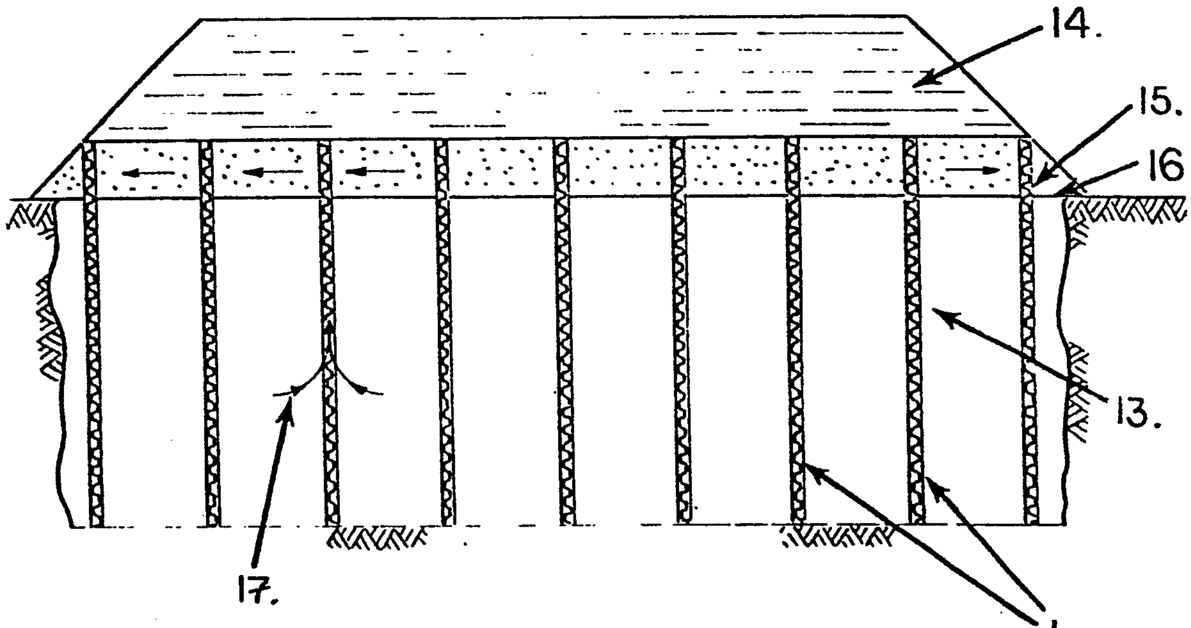

FIG 11.

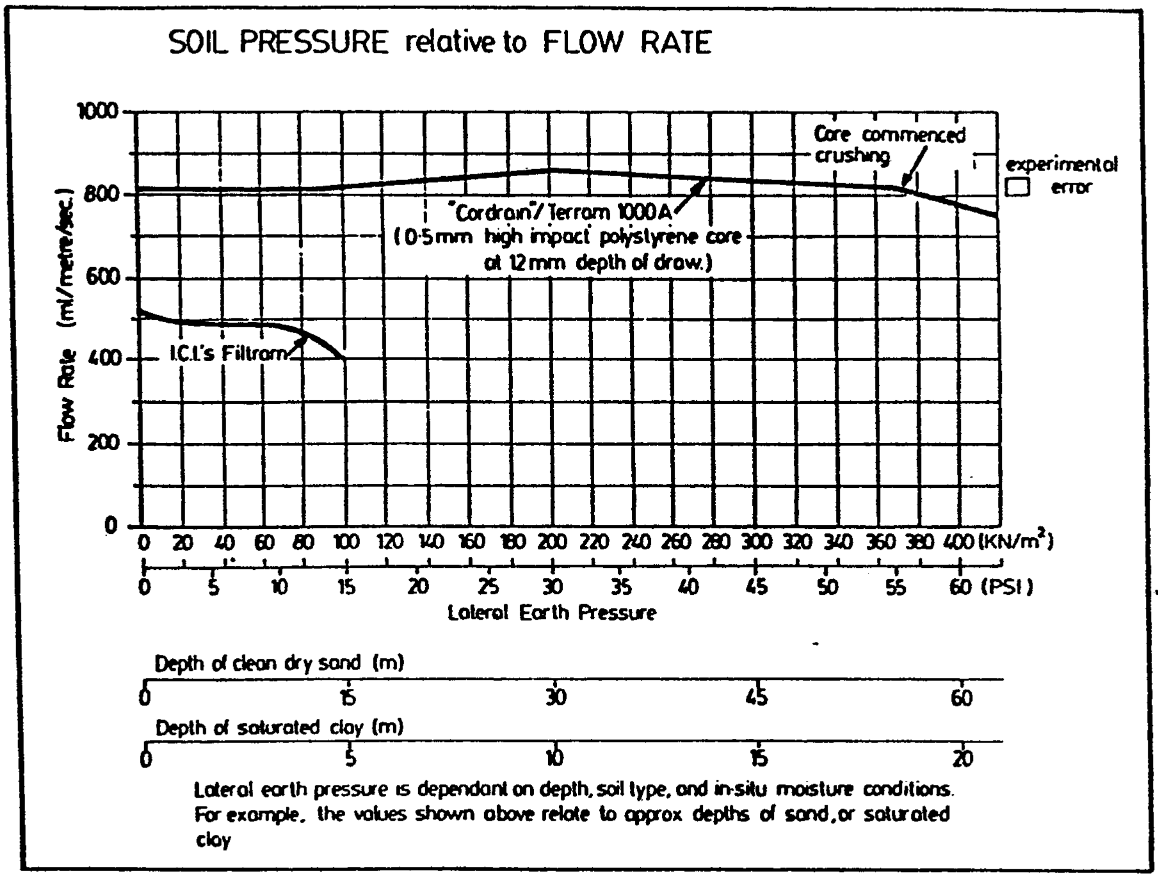
SOIL PRESSURE relative to FLOW RATE
Flow Rate (ml/metre/sec.)
1000
800
600
400
200
0
Core commenced crushing
experimental error
"Cordrain"/ Terram 1000A
(0·5mm high impact polystyrene core at 12mm depth of draw.)
I.C.I.'s Filtram
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 (KN/m²)
0 5 10 15 20 25 30 35 40 45 50 55 60 (PSI)
Lateral Earth Pressure
Depth of clean dry sand (m)
0 15 30 45 60
Depth of saturated clay (m)
0 5 10 15 20
Lateral earth pressure is dependant on depth, soil type, and in-situ moisture conditions.
For example, the values shown above relate to approx depths of sand, or saturated clay

FIG 12.

European Patent Office

EUROPEAN SEARCH REPORT

0075993

EP 82 20 1169

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
Y	FR-A-2 319 068 (BURCAN) * page 5, lines 12-38; page 6; figures 1,2 *	1,3,4, 6,7,8	E 02 B 11/00 E 02 D 3/10 E 02 D 31/02
Y,D	FR-A-2 462 518 (COFRAD) * pages 5-7; figures 2,3 *	1,8	
X		3,4	
A	NL-A-7 801 574 (VAN DEN BERG) * pages 4-6; figures 1-4 *	1	
A,D	US-A-3 563 038 (HEALY)		**TECHNICAL FIELDS SEARCHED (Int. Cl. 3)**
A,D	US-A-3 654 765 (HEALY)		
A,D	US-A-3 963 813 (KEITH)		E 02 B E 01 C E 02 D A 61 G
A	CIVIL ENGINEERING-ASCE, vol.44, no.4, April 1974, New York (US) K.A. HEALY et al.: "Prefabricated, fin underdrain promises faster soil drainage", pages 50-54		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	06-01-1983	HANNAART J.P.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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& : member of the same patent family, corresponding document

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